

ISDN ALARM NOTIFICATION SYSTEM

FIELD OF THE INVENTION

The present invention relates to an ISDN alarm notification system for fault locating in subscriber transmission equipment being connected to switching equipment, and more particularly an ISDN alarm notification system in subscriber transmission equipment being connected to switching equipment conforming to TR303 standard.

BACKGROUND OF THE INVENTION

Recently a digital loop carrier service is being introduced mainly in North America for subscribers being 15 remotely located from switching equipment. The subscribers are connected to the switching equipment through multiplexed optical transmission lines.

In FIG. 1, a configuration example of a UDLC (Universal Digital Loop Carrier) system is shown. A DS0 level analog 20 output from an analog switch 1 is converted into a digital signal by means of digital loop carrier equipment 2, and is converted further to an optical multiplexed signal 4, such as OC3/OC12, by an add-drop multiplexer (ADM) 3. The signal is then forwarded to a remote terminal station 5 which accommodates a terminal located in a carrier service 25 area 6.

Also, a DS0 analog output from analog switch 1 is

converted into an optical multiplexed signal 8 through an access carrier transport system (ACTR) 7 having a dynamic cross connect function. The signal is then forwarded to a remote terminal station 9 which accommodates a terminal 5 located in a carrier service area 10.

In FIG. 2, there are shown digital switches (TR008 compliant and TR303 compliant), which output DS1 signals. Digital switches 11, 12 are connected oppositely to remote terminal stations 13, 14 of access carrier transport 10 systems (ACTR), constituting an Integrated Digital Loop Carrier (IDLC) system.

Here, a digital switch (TR008) 11 is one type of switching equipment which transmits/receives control signals through a service channel within each subscriber 15 line. A digital switch (TR303) 12 is another type of switching equipment which uses a different path for control signal transmission through a dynamic cross connect.

The systems shown in FIGS. 1, 2 are described below in more detail. Conventional analog switches 1A - 1C have 20 the identical interface, irrespective of the switching equipment vendors, conforming to the identical interface standard (TR-008). Regarding ISDN in particular, alarm notification and fault locating method is specified by TR-397 standard.

25 In addition, a central office terminal (COT) 20 and a remote terminal station (RT) (or, subscriber transmission equipment) 21 being located between switches 1A - 1C and

subscriber terminal equipment 22 constitute the UDLC structure shown in FIG. 1, which is so called 'invisible existence'.

Therefore, in designing both central office terminal 5 (COT) 20 and remote terminal (RT) 21, it was not necessary to take switching equipment vendors into consideration. Basically it is possible to transmit signals between switches 1A - 1C and subscriber terminals 22 without modification (i.e. transparently).

10 More specifically, in TR-008 mode, it is possible to send a common m-bit and a control path message (eoc: embedded operation channel) using the identical specification without regard to the switching equipment vendors in the event of an ISDN alarm condition.

15 In table 1 shown in FIG. 4, there is illustrated ISDN alarm notification command and the values thereof (TR-008) applicable to every switching equipment vendor. For example, in the case of CH card extraction listed in item 1, on detection of an interface LUNT in central office terminal 20 (COT) 2 being not installed, m-bit = '0111 1110 111'b is sent to switch 1.

Each bit is named (from left to right) as act, ps1, ps2, ntm, cso, m46, sai, nib, m51, m52 and m61. In the above case, act and nib are '0', while the others are '1'.

25 Also, in the case of item 1, eoc message having addr. = 1 and msg = '78' is sent to switch 1. Here, addr. = 1 denotes LUNT (COT side), addr. = 2 denotes LULT (RT side),

and addr. = 0 denotes NT1, respectively. According to the indication of msg = '78' which denotes 'loss of synchronization', it is to be understood that an alarm condition occurs in interface LULT corresponding to addr.

5 = 2, causing an alarm sent from addr. = 1 to switch 1.

Similarly, in the case of loss of synchronization at reference point U shown in item 2, m-bit is also sent as in the case of item 1, while eoc address is changed to '2'.

In the case of NT1 power off shown in item 3, m-bit  
10 and control path (eoc) are sent, similarly to item 2, because the state is moved to the loss of synchronization at point U which is the same as item 2.

In the case of loss of synchronization at reference point T shown in item 4, both act bit and sai bit are '0'  
15 and the remainder bits are '1'. Even the synchronization is lost at point T, the synchronization to network terminal NT1 is still in established condition. Therefore, control path (eoc) having '7', which denotes a broadcast address, and a message having 'FF', which denotes 'return to normal'  
20 are sent.

#### SUMMARY OF THE INVENTION

There exists a problem in subscriber transmission equipment conforming to TR-303 standard that alarm information of an ISDN subscriber is not correctly recognized by switching equipment manufactured by a certain vendor (Nortel Networks).

In the IDLC configuration shown in FIG. 2 conforming to TR-303 standard, a signal between switching equipment and a subscriber cannot be transmitted transparently, unlike the case of UDLC configuration.

5 More specifically, subscriber alarm information is managed by the subscriber transmission equipment RDT, to be transmitted using a control path (eoc: embedded operation channel) between the switching equipment and the subscriber. According to an access carrier transport system  
10 (ACTR) being an object of the present invention, a 4:1 time-division multiplexing (TDM) mode function is already added aiming to connect a data terminal (IDT).

In 4:1 TDM mode, control information is transmitted and received using control path (eoc: embedded operation  
15 channel) between switching equipment conforming to TR-303 standard and subscriber transmission equipment (RDT). However, in TR-397 standard related to ISDN, the details of eoc (on alarm notification of ISDN subscribers) are not clearly specified for 4:1 TDM mode.

20 Therefore, practically each manufacturer designs switching equipment based on the manufacturer's own ISDN alarm detection specification to support TR-303 interface.

Considering the aforementioned situation, according to the present invention, switch options (SWOPT) are  
25 provided in an ISDN card for the access carrier transport system (ACTR), so as to make it possible to transmit and receive ISDN alarm notification corresponding to the

vertical margin line on the left side of the page.

respective switching equipment provided by different venders.

According to the present invention, a preferred embodiment of an ISDN alarm notification system includes 5 digital switching equipment; subscriber transmission equipment connected to the switching equipment; and a controller for setting switch options externally, the subscriber transmission equipment including, a switching equipment interface unit, a control path unit, and an ISDN 10 subscriber interface unit. Switch options provided in the switching equipment interface units, the control path unit and the ISDN subscriber interface unit are set from the controller, so that switch options are set the same, corresponding to the digital switching equipment connected 15 to the subscriber transmission equipment.

Further, the switch options in the ISDN subscriber interface unit are alarm controllers corresponding to the digital switching equipment.

As another embodiment of the present invention, the 20 ISDN alarm notification system includes a plurality of digital switching equipment; subscriber transmission equipment connected to the plurality of switching equipment; and a controller for setting switch options externally, the subscriber transmission equipment including, switching equipment interface units, a control path unit, and an ISDN subscriber interface unit. Switch 25 options provided in the switching equipment interface units,

the control path unit and the ISDN subscriber interface unit are set from the controller, so that switch options are set the same, corresponding to the plurality of digital switching equipment connected to the subscriber transmission equipment.

Preferably the switch options in the ISDN subscriber interface unit are alarm controllers corresponding to the digital switching equipment.

Still further, in the above-mentioned ISDN alarm notification system, the plurality of digital switching equipment provide interfaces conforming to RDT301-1 to -4 standards, and each switching equipment type corresponding to each RDT303 standard can be set into the switching equipment interface unit, control path unit, and ISDN subscriber interface unit in the subscriber transmission equipment.

Also, in the above-mentioned ISDN alarm notification system, the plurality of digital switching equipment are products of different vendors.

Still further, as another embodiment of the present invention, an ISDN alarm notification system includes a plurality of digital switching equipment; and analog switching equipment having, subscriber transmission equipment connected to the plurality of digital switching equipment through digitizing equipment directly, and a controller for setting switch options externally. The subscriber transmission equipment includes, switching

equipment interface units, a control path unit, and an ISDN subscriber interface unit, and switch options provided in the switching equipment interface units, the control path unit and the ISDN subscriber interface unit are set from 5 the controller, so that switch options are set the same, corresponding to the plurality of digital switching equipment connected to the subscriber transmission equipment.

Still further, preferably, the ISDN subscriber 10 interface unit includes alarm controllers of identical configuration corresponding to a plurality of channels to be connectable to a plurality of different switching equipment modes on a channel by channel basis.

Also, preferably the ISDN subscriber interface unit 15 includes alarm controllers for at least two channels in one ISDN card.

Further, the ISDN subscriber interface unit includes a terminator, which detects an uninstalled condition of an ISDN channel card.

20 Still further, the ISDN subscriber interface unit includes a terminator, which detects a disconnected condition of a network terminal.

Still further, the ISDN subscriber interface unit 25 includes a terminator, which detects a power off condition of a network terminal.

Further scopes and features of the present invention will become more apparent by the following description of

the embodiments with the accompanied drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a configuration example of the UDLC  
5 (Universal Digital Loop Carrier) system.

FIG. 2 shows a configuration example of the IDLC  
(Integrated Digital Loop Carrier) system.

FIG. 3 shows an explanation drawing of the conventional  
10 technique conforming to the identical interface standard  
TR-008, irrespective of the switching equipment venders.

FIG. 4 shows examples of ISDN alarm notification  
commands and the values (TR-008) corresponding to  
respective switching equipment of different venders.

FIG. 5 shows an explanation drawing illustrating an  
15 outline of the present invention.

FIG. 6 shows a drawing illustrating a configuration  
example of subscriber transmission equipment according to  
the present invention.

FIG. 7 shows a drawing illustrating a configuration  
20 example of a point U terminator shown in FIG. 6.

FIG. 8 shows a configuration drawing of an embodiment  
of subscriber transmission equipment according to the  
present invention.

FIG. 9 shows an explanation drawing of ISDN alarm  
25 notification commands and the values (TR-303)  
corresponding to respective switching equipment of  
different venders.

PREFERRED EMBODIMENTS OF THE INVENTION

The preferred embodiments of the present invention are described hereinafter referring to the charts and 5 drawings, wherein like numerals or symbols refer to like parts.

In FIG. 5, there is shown an embodiment of the present invention illustrating a conceptual configuration of the invention. As shown in FIG. 5, when connecting to digital 10 switches 2A to 2D having TR-303 standard interfaces, a central office terminal (COT) 20 is not required. A remote digital terminal (RDT) 21 constituting subscriber transmission equipment is directly connected to the switches 2A to 2D via DS1 signals.

15 Here, the interface specification (ISDN alarm detection method) is differently defined in each digital switch 2A to 2D having TR-303 interface standard. Therefore, uniquely defined alarm information cannot be applied, and ISDN alarm notification scheme must be differently 20 specified depending on each type of the switching equipment.

For this reason, according to the present invention, a switch option SWOPT is set from a computer (PC) 24 connected to subscriber transmission equipment (ACTR: access carrier 25 transport system) 21 so as to make it possible to transmit ISDN alarm notification corresponding to each switching equipment.

In FIG. 6, there is shown a configuration example of subscriber transmission equipment and other equipment, illustrating the principle of the present invention. In FIG. 6, a TR-303 digital switch SW1 provided by one vendor 5 (vender -A) is connected to subscriber transmission equipment 21 through DS1. A switch (SW) interface card 211 in subscriber transmission equipment 21 is provided with SW interfaces 211a to 211d, and an SWOPT setting portion 211e for setting the switch options to SW interfaces 211a 10 to 211d.

Switch options SWOPT1, 2 or 3 in each SW interface 211a to 211d can be set from SWOPT setting portion 211e. Here, regarding switch SW1 of vender -A being connected to the first SW interface 211a, vender -A is defined as 15 SWOPT1 in subscriber transmission equipment 21. Accordingly, by controlling SWOPT setting portion 211e from computer (PC) 24 through a PC interface card 25, the first SW interface 211a is set into switch option SWOPT1.

Meanwhile, an EOC control card 212 includes EOC 20 controllers 212a to 212c. Here, EOC controller 212a (SWOPT1) controls the control path (eoc: embedded operation channel) through an EOC terminator 212e from SW interface 211a in which SWOPT1 is set by SWOPT setting portion 212d.

Further, this first EOC controller 212a transmits and 25 receives an internal EOC to/from an ISDN card 214 through an internal EOC transmitter/receiver 212f.

There is provided a cross connect card 213 between

an EOC control card 212 and ISDN card 214 to perform cross connect function. An operation mode of cross connect is determined by setting information transmitted from computer (PC) 24 to cross connect setting portion 213a 5 through PC interface card 25.

There are provided circuits for two channels in one ISDN card 214. Channel (CH) 1 and channel (CH) 2 in ISDN card 214 are shown in the figure. The circuit structure is identical between each channel, having a first alarm 10 controller 214a, a second alarm controller 214b and a third alarm controller 214c to issue alarm notification to SWOPT1 to SWOPT3, respectively.

For example, a connection is established to cross connect setting portion 213a in cross connect card 213 by 15 computer (PC) 24, so that CH1 is connected to switch SW1. After this connection is established, alarm controller 214a is set effective from EOC control card 212 so that CH1 in ISDN card 214 performs alarm control against SWOPT1.

Based on the above-mentioned structure, for example 20 when ISDN card is removed (i.e. shifted to uninstalled state), EOC controller 212a and EOC controller 212b in EOC control card 212 respectively inform the first and second switches SW1, SW2 of alarm notification indicating the transitions of CH1 and CH2 to uninstalled state.

25 Also, when point U of CH1 is shifted to loss of synchronization condition, namely a point U terminator 214d is not connected to network terminal NT1, point U terminator

214d of CH1 detects the loss of synchronization at point U. Then alarm controller 214a transmits an alarm command conforming to SWOPT1 specification from an internal EOC transmitter/receiver 214e to the switching equipment.

5       Similarly, when point U of CH2 is shifted to loss of synchronization condition, point U terminator 214d of CH2 detects the loss of synchronization at point U. Then alarm controller 214b transmits an alarm command conforming to SWOPT2 specification from an internal EOC transmitter/receiver 214e to the switching equipment.

10      When point T of CH1 (located between network terminal NT1 and terminal equipment TE) is shifted to loss of synchronization condition, network terminal NT1 transmits the information of loss of synchronization at point T to 15 alarm controller 214a of CH1 in ISDN card 214 through point U using m-bit. Alarm controller 214a then transmits control path eoc on the occurrence of loss of synchronization at point T according to an alarm notification method expected by the vendor -A of the switching equipment.

20      In FIG. 7, a detailed configuration example of point U terminator 214d is shown. Point U terminator 214d includes an alarm controller switch 200, a loss of synchronization detector (point U) 201, an NT1 power off detector 202, and a loss of synchronization detector (point T) 203.

25      It should be noted that the value of m-bit for notifying loss of synchronization at point T varies depending on the type of network terminal NT1. Namely, in one case the

notification is carried out using either ACT = 0. In other cases, the notification is carried out using SAI = 0, or both act = 0 and sai = 0.

It is necessary to detect loss of synchronization 5 condition at point T in any type of network terminal NT1. For this purpose, as shown in FIG. 7, in loss of synchronization detector (point T) 203 of point U terminator 214d, there are provided a circuit 203b for detecting ACT = 0, and a circuit 203c for detecting SAI 10 = 0, and further an OR circuit 203a for making OR between the outputs of circuit 203b and circuit 203c.

Accordingly, the loss of synchronization at point T is detected by determining either act bit or sai bit becomes "0".

15 In addition, if this m-bit is transmitted directly to the switching equipment, the loss of synchronization at point T is not detected by the switching equipment. Therefore, a measure is taken that a control path alarm report is transmitted from alarm controller 214a after 20 converting the m-bit value to the value of LT OH or NT OH expected by vendor -A of switching equipment SW1.

Accordingly, the loss of synchronization at point T is accurately notified to any type of switching equipment if any type of network terminal NT1 is connected to ISDN 25 card 214.

In FIG. 8, an embodiment of the present invention is shown. In this figure, two types of switching equipment

are connected as TR-303 digital switches: #5ESS (manufactured by Lucent Technologies) as first switching equipment SW1, and DMS-100 (manufactured by Nortel Networks) as second switching equipment SW2.

5 As switch options, RDT303-1 : SWOPT = 1 (for the Lucent  
switch) and RDT303-2 : SWOPT = 2 (for the Nortel switch)  
are set by computer (PC) 24.

Here, RDT303-1 and RDT303-2 are interfaces 211a and 211b provided in SW interface card 211 respectively to interface with the first and the second switching equipment. CH1 and CH2 in ISDN card (D-BRU-LT2) 214 is cross-connected to interface 211a (RDT303-1) and interface 211b (RDT303-2) using a cross connect card 213.

By this cross connect, the same switch option SWOPT  
15 as in RDT303-1 and RDT303-2 is set in CH1 and CH2 of ISDN  
card 214. Also, an EOC controller in EOC control card (EMIC)  
212 operates based on the specification corresponding to  
switch option SWOPT.

Here, it is possible to identify maximum four types  
20 of switching equipment in one subscriber transmission  
equipment (RDT). 21. Independent types of switching  
equipment can be set in each of four interfaces: RDT303-1,  
RDT303-2, RDT303-3 and RDT303-4.

In FIG. 9, there is shown as table 2 a list of ISDN alarm notification commands and values in ISDN card (D-BRU-LT2) 214 corresponding to each vendor of the switching equipment.

Among the vendors, switch option SWOPT = 1 is allocated for both Lucent Technologies and Siemens AG, and switch option SWOPT = 2 is allocated for Nortel Networks, respectively to handle notification commands.

5 In regard to switch option SWOPT = 3 is not used at present because there is no other supporting vendors. However, the equipment is designed so as to operate by the software of previous version developed before the present invention. This backward compatibility enables to prevent  
10 an abnormal operation in the case the equipment having only EOC control card updated is used.

In the description shown in the table of FIG. 9, there are shown EOC information notification to be transmitted from subscriber transmission equipment (RDT) 21 to the  
15 switching equipment. Here, 'LTOH' and 'NTOH' respectively denote the m-bit on downward direction of point U (LT OH) and the m-bit on upward direction (NT OH).

In the table of FIG. 9, in the case of unloaded CH card listed in item 1, only "M\_EVENT\_REPORT for ISDN Line  
20 Termination" is transmitted when the switch option SWOPT = 1 is set. However, when the switch option SWOPT = 2 is set, it is required to transmit "M\_EVENT\_REPORT for ISDN Framed Path Termination Change of Overhead Bits Report", in addition to "M\_EVENT\_REPORT for ISDN Line Termination".

25 When transmitting the "M\_EVENT\_REPORT for ISDN Framed Path Termination Change of Overhead Bits Report", the information of LT OH and NT OH shown in table 2 is also

included.

In the case of loss of synchronization at point U listed in item 2, the loss of synchronization having been detected in loss of synchronization detector (point U) 203 provided 5 in point U terminator 214d is transmitted as an alarm to the switching equipment. In this case, only "Alarm Status Change Report" must be transmitted to the switching equipment when the switching equipment is manufactured by either Lucent Technologies or Siemens AG having the switch 10 option SWOPT1.

Also, the act bit of LT OH is to be set to '0', and all bits of NT OH are to be set to '0'. Meanwhile, to the switching equipment manufactured by Nortel Networks having the switch option SWOPT2, "Alarm Status Change Report" and 15 "NT1 Overhead Status Change Report" must be transmitted. Also the act bit of LT OH is to be set to '0', and the act, ps1, ps2 and sai bits of NT OH are to be set to '0'.

In the case of NT1 power off listed in item 3, the condition becomes the same as the condition of loss of 20 synchronization at point U. Therefore the transmission message is the same.

In the case of loss of synchronization at point T listed in item 4, the loss of synchronization having been detected in the loss of synchronization detector at point T provided 25 in point U terminator is transmitted as an alarm to the switching equipment. In this case, the switching equipment to which the switch option SWOPT1 is allocated detects the

loss of synchronization at point T, if the act bit of LT OH is '1' and the act bit of NT OH is '0', while the switching equipment to which the switch option SWOPT2 is allocated detects the loss of synchronization at point T, if the act 5 bit of LT OH is '1', and both the act bit and sai bit of NT OH are '0'.

Thus, by transmitting the values shown in table 2 of FIG. 9, the loss of synchronization at point T can be detected in the switching equipment.

10

#### INDUSTRIAL APPLICABILITY

As the embodiments having been described, according to the present invention, it is not necessary to substitute an equipment module or the like for connecting to a digital 15 switch having TR303 standard. The connection can be conducted by simple modification of adding software function to be installed in an ISDN card.

When a network terminal NT1 of different type is connected to an ISDN subscriber, it is possible to transmit 20 an ISDN alarm accurately to any TR-303 digital switch, while maintaining the conventional services (TR-008 POTS/ISDN, TR-303 POTS/ISDN). This contributes to accurate maintenance work of fault locating of subscriber lines.

The foregoing description of the embodiments is not 25 intended to limit the invention to the particular details of the examples illustrated. Any suitable modification and equivalents may be resorted to the scope of the invention.

All features and advantages of the invention which fall within the scope of the invention are covered by the appended claims.

10004006.112801